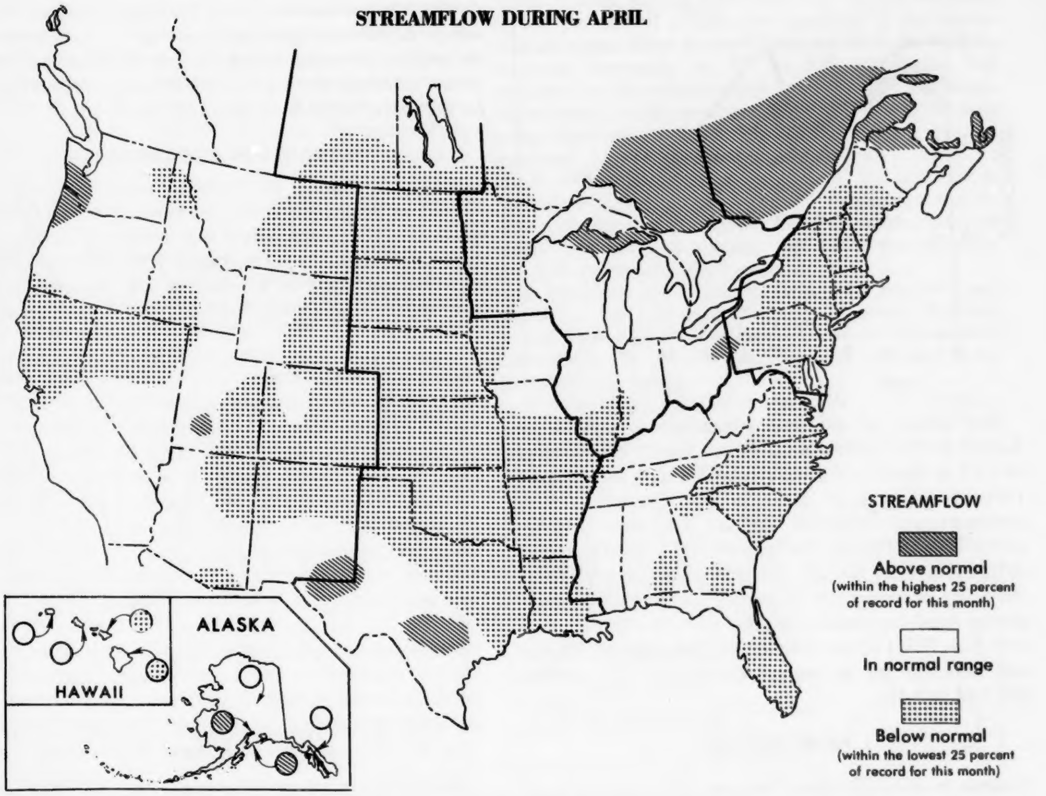
WATER RESOURCES REVIEW for APRIL 1981

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

CANADA
DEPARTMENT OF THE ENVIRONMENT
WATER RESOURCES BRANCH

STREAMFLOW DURING APRIL



STREAMFLOW AND GROUND-WATER CONDITIONS

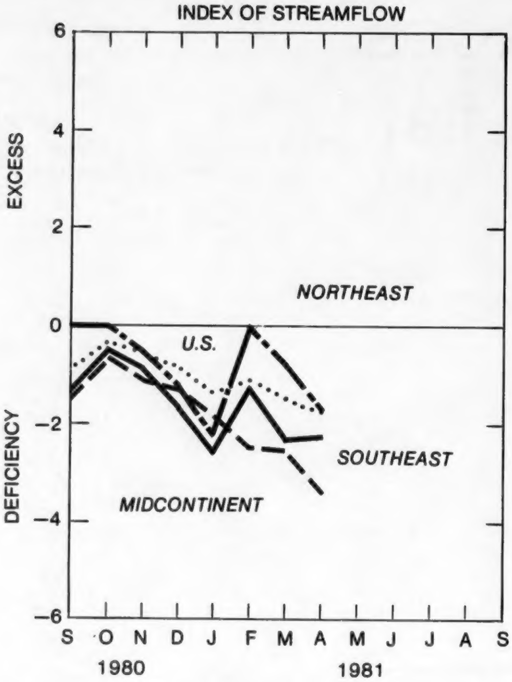
Streamflow generally increased in southern Canada, most northern areas of the conterminous United States, and also in Alabama, Georgia, Kentucky, Tennessee and West Virginia. Monthly mean flows decreased in Kansas, Rhode Island, and South Carolina, and were variable elsewhere.

Monthly mean flows remained in the below-normal range in parts of every State and Province except Alaska, Alberta, British Columbia, New Brunswick, Kentucky, Maine, Michigan, Mississippi, New Hampshire, Nova Scotia, Ohio, Oregon, Vermont, West Virginia, and Wisconsin, and were lowest of record for April in parts of Louisiana, Maine, Nebraska, New Mexico, North Carolina, Virginia, and Wyoming. Voluntary water-conservation measures were in effect in parts of Florida.

Flows remained in the above-normal range in parts of the Atlantic Provinces, Ontario, Quebec, New Mexico, and Texas, and increased into that range in parts of Michigan, Ohio, Oregon, Tennessee, Utah, and Washington. Monthly mean flows were highest of record for the month in parts of Alaska. Flooding occurred in Illinois, Indiana, Ohio, and Texas.

Ground-water levels reversed a falling trend and rose in the northern and western parts of the Northeast Region, but declined in the southern parts. Levels were far below average in most eastern parts of the region. In the Southeast Region, levels rose in Kentucky, declined in Alabama and West Virginia, and showed mixed trends in other Sstates. Levels were above average in Kentucky, below average in Alabama, North Carolina, Tennessee, Virginia, and West Virginia, and above and below average elsewhere. In the Western Great Lakes Region, ground-water levels were below average in Minnesota and Michigan and above average elsewhere. Levels were near or above average in Wisconsin, Illinois, Indiana, and Ohio, and below average in other States. Levels in the Midcontinent Region rose in North Dakota and Nebraska, declined in Kansas and Texas, and showed mixed trends elsewhere. Levels were generally below average. In the West, levels rose in Washington, declined in Arizona, and showed mixed trends in other States. Levels were below average in Idaho, Arizona, and New Mexico, and above and below average elsewhere.

A new high ground-water level for April was again reached in Utah. New April lows occurred in Arkansas, Kansas, Louisiana, Nebraska, Tennessee, Texas, Utah, and Virginia. New alltime highs were recorded in southern California and Illinois, and new alltime lows were reached in Arizona and Idaho.



The index of deficient streamflow continued to worsen in the conterminous United States from a value of −1.5 in March to a value of −1.8 in April, as low flows prevailed over large areas in the Northeast, Midcontinent, and Southeast Regions. The index is computed by multiplying the percent of a region that is deficient by the average duration of deficiency. Thus, the index of streamflow deficiency for the Midcontinent during April decreased to a value of −3.4 when 83 percent (i.e., 0.83) of the area in the Midcontinent Region was deficient for an average duration of 4.1 months (0.83X4.1=3.4).

NORTHEAST

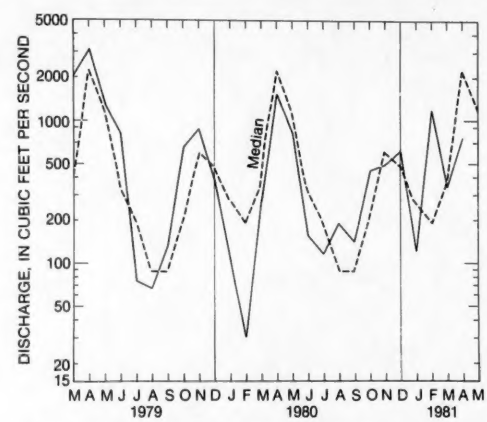
[Atlantic Provinces and Quebec; Delaware, Maryland, New York, New Jersey, Pennsylvania, and the New England States]

Streamflow decreased seasonally in Rhode Island, was variable in Connecticut and New York, and increased elsewhere in the region. Monthly mean flows remained in the below-normal range in parts of Connecticut, Maryland, Massachusetts, New Jersey, New York, Pennsylvania, and Rhode Island, and decreased into that range in parts of Quebec, Maine, New Hampshire, and Vermont. Monthly mean discharges remained in the above-normal range in parts of Quebec and the Atlantic Provinces. Mean flows were lowest of record for the month in parts of Maine.

Ground-water levels rose in most of New England and in western parts of New York and Pennsylvania. Levels declined in southeastern New York and northern New Jersey. Levels were again below average in many parts of the region, including much of New England and New Jersey. Levels in some wells were near or at lowest levels for the end of April in 30 years of record.

STREAMFLOW CONDITIONS

In central Maine, the monthly mean discharge of 754 cfs in Piscataquis River near Dover-Foxcroft (drainage area, 297 square miles) was lowest of record for April since records began in August 1902, and was in the below-normal range as a result of low carryover flow from March. (See graph.) Similarly, in the southern part of the State, the monthly mean discharge of 188 cfs in Little Androscoggin River near South Paris (drainage



Monthly mean discharge of Piscataquis River near Dover-Foxcroft, Maine (Drainage area, 297 sq mi; 769 sq km)

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area, 76.2 square miles) was lowest for April in 60 years of record. In the northern part of the State, mean flow of St. John River below Fish River, at Fort Kent increased sharply but was within the normal range at 144 percent of median.

In northern New Brunswick, monthly mean discharge of Upsalquitch River at Upsalquitch continued to increase seasonally and remained in the above-normal range for the 3d consecutive month. Similarly, in northern Nova Scotia, mean flow of Northeast Margaree River at Margaree Valley increased seasonally, remained in the above-normal range for the 3d consecutive month, and was 193 percent of median. Elsewhere in the Atlantic Provinces, mean flows at index stations increased seasonally but remained in the normal range.

South of the St. Lawrence River in southern Quebec, mean flow of St. Francois River at Hemmings Falls increased seasonally but was only 58 percent of median and was below the normal range. In eastern Quebec, monthly mean discharge of Matane River near Matane increased seasonally, was 142 percent of median, and remained in the above-normal range for the 3d consecutive month. North of the St. Lawrence River, monthly mean flows at index stations increased seasonally, were more than twice the median flows for April, and remained in the above-normal range.

Streamflow was below the normal range throughout central New England and ranged from a low of 33 percent of median in southwestern Massachusetts to a high of 71 percent of median in central New Hampshire. Monthly mean flow at the index station, West Branch Westfield River at Huntington, Massachusetts, was lowest for April for period of record that began in September 1935. Storage in major reservoirs increased and ranged from 82 to 153 percent of average near the end of April. Total contents of all index reservoirs was about 89 percent of that of a year ago.

In Connecticut, streamflow generally remained in the below-normal range except in the southeastern part of the State, where mean flow of Salmon River near East Hampton increased, contrary to the normal seasonal pattern, and was in the normal range but only 68 percent of median.

In New York, streamflow was down to levels normally experienced in late May and June as a result of below-average precipitation, and mean flows at all index stations were below the normal range. Flows for April were the lowest since 1946 at Hudson River at Hadley, Schoharie Creek at Prattsville, Mohawk River at Cohoes, and Beaver Kill at Cook Falls. On Long Island, monthly mean discharge of Massapequa Creek at Massapequa decreased seasonally and remained in the below-normal range for the 8th consecutive month. In the south-central part of the State, flow of Susquehanna River at Conklin decreased, contrary to the normal seasonal pattern of increasing flow, was only 40 percent of median, and remained in the below-normal range.

Downstream in Pennsylvania, monthly mean flow of Susquehanna River at Harrisburg increased slightly to 46 percent of median but remained in the below-normal range for the 2d consecutive month. Similarly, in the northwestern part of the State, monthly mean discharge of Allegheny River at Natrona increased to 76 percent of median but also remained in the below-normal range. Elsewhere in the State, monthly mean flows at index stations increased, contrary to the normal seasonal pattern, were near or above median, and generally within the normal range.

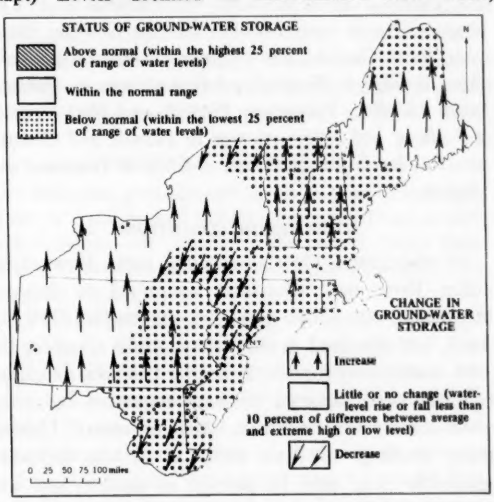
In northern New Jersey, monthly mean discharge of South Branch Raritan River near High Bridge increased to 69 percent of median but remained in the below-normal range. Mean flow of Delaware River at Trenton increased seasonally to 37 percent of median but remained in the below-normal range for the 2d consecutive month. In the southern part of the State, monthly mean discharge of Great Egg Harbor River at Folsom increased to 74 percent of median as a result of above-normal precipitation during April, but remained in the below-normal range for the 6th consecutive month. Reservoir contents throughout the State were considered about 70 percent of capacity, well below the normal of 90–100 percent for this time of the year.

In Maryland and Delaware, streamflow increased and was within the normal range except in central Maryland where mean flow of Seneca Creek at Dawsonville increased to 73 percent of median but remained in the below-normal range.

Monthly mean flow of Potomac River near Washington, D.C. increased sharply, as a result of runoff from rains near mid-month, and was within the normal range at 80 percent of the April median flow.

GROUND-WATER CONDITIONS

Ground-water levels rose in most of New England and in western parts of New York and Pennsylvania. (See map.) Levels declined in southeastern New York,



Map shows ground-water storage near end of April and change in ground-water storage from end of March to end of April.

northern New Jersey, and southern Maryland. Levels were below average in most of the region other than western New York and Pennsylvania. Near end of month the levels in some observation wells in New England, New Jersey, Delaware, southeastern Pennsylvania, and southern Maryland were unusually low for this time of year.

SOUTHEAST

[Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia]

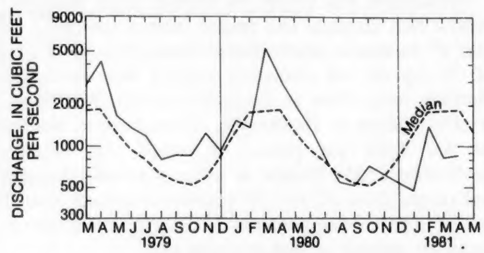
Streamflow generally increased, contrary to the normal seasonal pattern, in Georgia, Kentucky, Mississippi, Tennessee, Virginia, and West Virginia, generally decreased in Florida, North Carolina, and South Carolina, and was variable in Alabama. Monthly mean discharge remained below the normal range at 18 of the 37 index stations in the region and was lowest of record for April at 4 of the 18. Below-normal flows have persisted for 10 months in parts of Florida, for 8 months in parts of Virginia, and for 5 months in parts of Georgia, North Carolina, South Carolina, and Tennessee. In Florida, municipal and State water-management officials were reported to have requested voluntary water-conservation measures in central and southern parts of the State. In west-central Tennessee, representatives of Duck River Development Association were reported to be concerned about the below-normal level of storage in Normandy Reservoir.

Ground-water levels rose in most wells in Kentucky, and declined in most wells in Alabama and West Virginia. Trends were mixed in Florida, Georgia, Mississippi, North Carolina, and Virginia. Levels were generally above average in Kentucky, below average in Alabama, North Carolina, Tennessee, Virginia, and West Virginia, and above and below average in Florida and Georgia. New low levels for April were reached in Tennessee and Virginia.

STREAMFLOW CONDITIONS

In east-central Florida, monthly mean flow of St. Johns River near Christmas continued to decrease seasonally, was about one-third the median flow for April, and remained in the below-normal range for the 10th consecutive month. In nearby Orlando, municipal officials were reported to have requested voluntary water-conservation measures. Also in central Florida, mean discharge of Peace River at Arcadia decreased seasonally, was only 16 percent of median, and was below the normal range for the 9th time in the past 10 months. In southern Florida, monthly mean flow of Fisheating Creek at Palmdale decreased to 2 percent of median, and water-management officials in that part of the State were reported to have requested voluntary water-use restrictions. The decline of flow into, and storage in major reservoirs, such as Lake Okeechobee, was causing concern. At monthend, storage in Lake Okeechobee was only 29 percent of usable capacity and the lake level was only slightly above that at which commercial barge traffic in the intercoastal waterway through the lake begins to be hampered. In the northwestern part of the State, mean flow of Shoal River near Crestview decreased seasonally, was about one-half the April median flow, and was below the normal range for the 4th time in the past 5 months.

In the Suwannee River basin in southeastern Georgia, monthly mean discharge of Alapaha River at Statenville increased, contrary to the normal seasonal pattern, but remained in the below-normal range for the 5th consecutive month and for the 9th time in the past 10 months. In the extreme northern part of the State, mean flow of Etowah River at Canton also increased but remained below the normal range for the 4th time in the past 5 months. (See graph.) At other index stations



Monthly mean discharge of Etowah River at Canton, Ga. (Drainage area, 605 sq mi; 1,570 sq km)

in Georgia, streamflow increased and was within the normal range.

In South Carolina, monthly mean flows decreased seasonally and remained below the normal range at all index stations in the State. For example, in the northeastern part of the State, mean discharge of Pee Dee River at Peedee continued to decrease, was only 28 percent of the April median flow, and remained in the below-normal range for the 5th consecutive month. In the adjacent basin of Lynches River, monthly mean flow at Effingham also continued to decrease, was only 34 percent of median, and was below the normal range for the 4th consecutive month. In central South Carolina, mean discharge of North Fork Edisto River at Orangeburg also decreased, and was below the normal range for the 3d time in the past 4 months.

In the Coastal Plain of North Carolina, the monthly mean discharge of 214 cfs, and the daily mean of

105 cfs on April 30, at the index station, Contentnea Creek at Hookerton (drainage area, 729 square miles) were lowest for April since records began in November 1928. In the eastern Piedmont, mean flow of Cape Fear River at William O. Huske Lock near Tarheel decreased seasonally, was only 30 percent of median, and remained below the normal range for the 5th consecutive month. Also in the eastern Piedmont, the monthly mean discharge of 431 cfs in Deep River at Moncure (drainage area, 1,410 square miles) was lowest for April since records began in July 1930, and was below the normal range for the 8th time in the past 10 months. In the central Piedmont, mean flow of South Yadkin River near Mocksville increased, contrary to the normal seasonal pattern, but remained below the normal range for the 5th consecutive month. In the mountain region of western North Carolina, the mean discharge of 1,480 cfs in French Broad River at Asheville (drainage area, 945 square miles) was the second lowest for April since records began in October 1895. The lowest April mean flow of record was 1,255 cfs in 1967.

In northern Virginia, where mean discharge of Slate River near Arvonia (drainage area, 226 square miles) was lowest of record for March, the mean flow of 86.0 cfs was lowest of record for April since records began in April 1926, and was below the normal range for the 8th consecutive month. Also, the daily mean discharge of 59 cfs on April 30 was lowest of record for the month. In the central part of the State, the monthly mean discharge of 206 cfs in Rapidan River near Culpeper (drainage area, 472 square miles) was lowest for April since records began in October 1930. In southeastern Virginia, mean flow of Nottaway River near Stony Creek was about one-third the April median discharge, and remained in the below-normal range for the 5th consecutive month. In extreme southwestern Virginia, monthly mean flow of North Fork Holston River near Saltville increased, contrary to the normal seasonal pattern, and was in the normal range, following 4 consecutive months of below-normal flow. In south-central Virginia, the monthly mean discharge of 3,590 cfs in James River at Cartersville (drainage area, 6,257 square miles) was the 2d lowest for April since records began in 1899.

In extreme northern West Virginia, where monthly mean discharge of Potomac River at Paw Paw was lowest of record for March, mean flow increased sharply, as a result of runoff from rains near midmonth, was near median, and was in the normal range. Elsewhere in the State, mean discharges also increased, contrary to the normal seasonal pattern, and were in the normal range.

In northern and southern parts of Kentucky, monthly mean flows at index stations increased, contrary to the normal seasonal pattern, were about 1½ times median, and were in the normal range.

In east-central Tennessee, mean discharge of Emory River at Oakdale increased sharply, in contrast to the normal seasonal pattern of decreasing flow, was about 1½ times the April median, and was in the above-normal range. In the north-central part of the State, mean flow of Harpeth River near Kingston Springs also increased, contrary to the normal seasonal pattern, was near median, and was in the normal range. In west-central Tennessee, monthly mean discharge of Buffalo River near Lobelville increased sharply, as a result of runoff from rains at the beginning of the month, and was in the normal range.

In central Mississippi, where monthly mean flow of Big Black River near Bovina was below the normal range in January, February, and March, mean discharge increased sharply in April and was in the normal range. In the southeastern part of the State, mean flow of Pascagoula River at Merrill also increased sharply, contrary to the normal seasonal pattern, and was in the normal range. In the adjacent basin of Pearl River, monthly mean discharge of Pearl River near Bogalusa, La., near the Mississippi-Louisiana boundary, increased contrary to the normal seasonal pattern, and was in the normal range.

In southeastern Alabama, mean flow of Conecuh River at Brantley decreased seasonally, was about one-half the April median discharge, and was below the normal range for the 4th time in the past 5 months. In the west-central part of the State, mean flow of Tombigbee River at Demopolis lock and dam, near Coatopa increased sharply and was in the normal range, following 3 consecutive months of below-normal flow. In extreme northern Alabama, where monthly mean flow of Paint Rock River near Woodville was lowest of record in March, flow increased sharply and the mean discharge during April was in the normal range.

GROUND-WATER CONDITIONS

In Alabama, ground-water levels in observation wells appear to have peaked for the spring and began a slow decline typical of summer. The water levels have declined a few tenths of a foot since mid-April, and continued below average.

In Florida, ground-water levels declined in most areas during April. Water levels ranged from about 2 feet lower at Tallahassee, Jacksonville, and Orlando, to nearly 6 feet lower near Mulberry in west-central Polk County. In contrast, levels rose from less than 1 foot near Ocala to about 4 feet at Pensacola in extreme northwestern Florida. Water levels ranged from 1.7 feet above average at Pensacola to 16.9 feet below average

near Mulberry. In southeastern Florida, water levels in 57 observation wells declined an average of 0.7 foot. End of month levels ranged from 1.7 feet below average in Palm Beach and St. Lucie Counties to 0.4 foot above average in South Dade County.

In Georgia, ground-water levels in the Piedmont were 0.1 to 0.4 foot higher than in March, but were nearly 3 feet lower than in April 1980. In the coastal counties, water levels in the principal artesian aquifer were 1 to 2 feet lower than last month. Near Savannah, levels ranged from 1.5 feet higher to 2 feet lower than last year and near Brunswick, were 2 to 4 feet lower. The level in the water-table aquifer was about 3 feet below median early in the month, but declined to about 1 foot above the low for the period of record for April. In southwest Georgia, water levels were about the same as in March, and were 13 to 20 feet lower than last year.

In Kentucky, ground-water levels declined slightly in the Louisville-Jefferson County area, but rose elsewhere, and generally were above average throughout the State.

In Mississippi, ground-water levels in the Sparta Sand continue to rise slightly in the Jackson Metro area. Levels in the Cockfield Formation showed declines of about 1 foot during April. Along the Gulf Coast and in southern Mississippi, the Citronelle, Graham Ferry, and Miocene aquifers remained about the same with the exception of wells in areas influenced by pumping where levels fluctuated. In northern Mississippi, the Wilcox and Upper Cretaceous aquifers indicated no change except near pumped wells where levels declined moderately. In Warren, Issaquena, and Yazoo Counties along the Yazoo River basin, water levels in the Mississippi River Alluvium aquifer rose from less than 1 foot to more than 2 feet, while levels in wells along the basin in Humphreys and Leflore Counties declined from less than 1 foot to almost 2 feet during the reporting period.

In North Carolina, ground-water levels rose slightly in the Mountain and Piedmont regions, and remained steady in the Coastal Plain. Levels in umpumped water-table wells were generally 1.5 to 2 feet below the long-term average for the month.

In western Tennessee, the artesian level in the key well in the 500 foot sand aquifer near Memphis declined 0.3 foot, and was nearly 15 feet below average, reaching a new April low in 40 years of record.

In Virginia, ground-water levels in three index wells in the Piedmont and Coastal Plain varied from a 0.6 foot rise in northern Virginia to a 0.6 foot decline in Louisa County. Water levels were 3 feet to 10.2 feet below long-term averages for these wells. A 29-year low for April was set at the Tyler well in Louisa County and a 42-year low was set at the Matoaka Manor well in Colonial Heights.

In West Virginia, ground-water levels declined throughout the northwestern quarter of the State during April, and remained the same or rose elsewhere. Ground-water storage was below average in the southeastern two-thirds of the State and above average elsewhere.

WESTERN GREAT LAKES REGION

[Ontario; Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin]

Streamflow decreased in parts of Ontario and Wisconsin but increased in all other parts of the region. Monthly mean flows remained below the normal range in parts of Illinois, Indiana, and Minnesota. Below-normal flows have persisted in southern Illinois for 6 months. Mean flows remained in the above-normal range in parts of Ontario and increased into that range in parts of Michigan and Ohio. Flooding occurred in Illinois, Indiana, and Ohio.

Ground-water levels rose in Minnesota, Wisconsin, Michigan, Illinois, Indiana, and Ohio, and were near or above average in Wisconsin, Illinois, Indiana, and Ohio. Water levels were below average in Minnesota and Michigan.

STREAMFLOW CONDITIONS

In northeastern Illinois, flooding occurred along the Illinois River near monthend, as reported by the National Weather Service. Rapid runoff from intense rainfall in that part of the State, augmented by high rates of inflow from the Kankakee and Iroquois River basins in adjacent areas of Indiana, resulted in flooding along Illinois River between Morris and Beardstown. In the northern part of the State, where mean flow of Pecatonica River at Freeport was only 49 percent of median, and was below the normal range in March, monthly mean discharge increased sharply into the normal range and was 108 percent of median. By contrast, in southern Illinois, mean flow of Skillet Fork at Wayne City remained in the below-normal range for the 6th consecutive month and was only 7 percent of median.

In northwestern Indiana, flooding occurred along Kankakee, Iroquois and Tippecanoe Rivers at midmonth. In northeastern and southeastern parts of the State, where monthly mean flows of Mississinewa River at Marion and East Fork White River at Shoals in March were lowest since 1941, flows increased sharply, as a result of runoff from rains on the 20th and 23d, and were in the normal range. In extreme southwestern Indiana, mean discharge of Wabash River, as measured at Mt. Carmel, Illinois, also increased but remained in the

(Continued on page 8.)

SELECTED DATA FOR THE GREAT LAKES, GREAT SALT LAKE, AND OTHER HYDROLOGIC SITES

GREAT LAKES LEVELS

Water levels are expressed as elevations in feet above International Great Lakes Datum 1955

(Data furnished by National Ocean Survey, NOAA, via U.S. Army Corps of Engineers office in Detroit. To convert data to elevations in feet above National Geodetic Vertical Datum of 1929 (NGVD), formerly called sea level datum of 1929, add the following values: Superior, 0.96; Michigan-Huron, 1.20; St. Clair, 1.24; Erie, 1.57; Ontario, 1.22.)

Lake	April 30, 1981	Monthly mean, April		April		
		1981	1980	Average 1900–75	Maximum (year)	Minimum (year)
Superior .... (Marquette, Mich.)	600.36	600.20	600.41	600.03	601.14 (1951)	598.23 (1926)
Michigan and Huron ...... (Harbor Beach, Mich.)	579.11	578.92	579.24	577.99	580.32 (1973)	575.36 (1964)
St. Clair .... (St. Clair Shores, Mich.)	574.72	574.38	575.13	573.28	575.91 (1973)	571.09 (1901)
Erie .... (Cleveland, Ohio)	571.78	571.47	572.40	570.51	573.30 (1973)	568.20 (1934)
Ontario .... (Oswego, N.Y.)	*244.84	244.70	245.52	245.01	247.69 (1973)	242.38 (1935)

LAKE WINNIPEG AT GIMLI, MANITOBA

Alltime high: 718.26 (July 1974). Alltime low: 709.62 (February 1941).	Monthly mean, April				
	1981	1980	Average 1913–80	Maximum (year)	Minimum (year)
Elevation in feet above NGVD:	712.53	713.78	713.15	716.38 (1975)	709.94 (1941)

GREAT SALT LAKE

Alltime high: 4,211.6 (1873). Alltime low: 4,191.35 (October 1963).	April 30, 1981	April 30, 1980	April		
			Average, 1904–80	Maximum (year)	Minimum (year)
Elevation in feet above NGVD:	4,200.05	4,199.40	4,199.00	4,205.10 (1924)	4,192.75 (1963)

LAKE CHAMPLAIN, AT ROUSES POINT, N.Y.

Alltime high (1827–1980): 102.1 (1869). Alltime low (1939–1980): 92.17 (1941).	April 29, 1981	April 30, 1980	April		
			Average, 1939–78	Max. daily (year)	Min. daily (year)
Elevation in feet above NGVD:	97.42	97.13	98.26	101.51 (1976)	94.11 (1965)

FLORIDA

Site	April 1981		March 1981	April 1980
	Discharge in cfs	Percent of normal	Discharge in cfs	Discharge in cfs
Silver Springs near Ocala (northern Florida)	710	93	700	780
Miami Canal at Miami (southeastern Florida)	0	0	0	50
Tamiami Canal outlets, 40-mile bend to Monroe	1	33	15.4	357

*Reading on April 29, 1981.

(Continued from page 6.)
below-normal range as a result of low carryover flow from March.

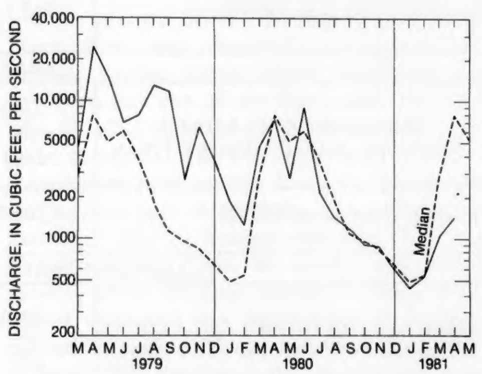
In eastern Ohio, flooding occurred in parts of Guernsey and Belmont counties, as reported by the National Weather Service. Also, in this part of the State, mean flow of Little Beaver Creek near East Liverpool increased sharply as a result of rapid runoff from intense rains at midmonth, was 1½ times the April median discharge, and was above the normal range. In the northwestern part of the State, where monthly mean discharge of Maumee River at Waterville was below the normal range and was only 30 percent of median in March, mean flow also increased sharply as a result of runoff from midmonth rains, and was in the normal range. Storage at monthend in reservoirs in the Scioto River basin upstream from Higby was 137 percent of last month, 103 percent of a year ago, and 104 percent of normal capacity. Storage at monthend in reservoirs in the Mahoning River basin upstream from Newton Falls was 143 percent of last month, 109 percent of a year ago, and 74 percent of capacity.

In southern Michigan, where mean flow of Red Cedar River at East Lansing was below the normal range in March, monthly discharge increased sharply, contrary to the normal seasonal pattern, was in the normal range, and was 115 percent of median. In the Upper Peninsula, mean flow of Sturgeon River near Sidnaw increased seasonally and remained above the normal range, as a result of high carryover flow from March augmented by runoff from rain and melting snow early in April. Lakes were ice free and near normal levels at monthend.

In extreme southeastern Ontario, monthly mean flow of Saugeen River near Port Elgin decreased, in contrast to the normal seasonal pattern, and remained in the normal range. In the eastern part of the Province, mean discharge of Missinaibi River at Mattice increased seasonally, was 172 percent of median, and remained above the normal range. In western Ontario, where monthly flow of English River at Umfreville was below the normal range in January, February, and March, monthly mean discharge increased sharply and was in the normal range.

In northwestern Wisconsin, where monthly mean flow of Chippewa River at Chippewa Falls was below the normal range in March, flow increased sharply and was within the normal range as a result of runoff from rains during the first week of April. In the eastern part of the State, mean flow of Fox River at Rapide Croche Dam, near Wrightstown decreased, in contrast to the normal seasonal pattern, but remained in the normal range for the 6th consecutive month. Elsewhere in the State, monthly mean discharges increased seasonally and remained in the normal range.

In northwestern Minnesota, the monthly mean discharge of 38 cfs in Roseau River below State Ditch 51, near Caribou (drainage area, 1,570 square miles) was lowest for April in 62 years of record. Also in this part of the State, the mean flow of 160 cfs in Wild Rice River at Hendrum (drainage area, 1,600 square miles) was lowest for the month in 37 years of record. In extreme northeastern Minnesota, monthly mean flow of Pigeon River at Middle Falls, near Grand Portage was 125 percent of median and was in the normal range, and mean flow of Basswood River near Winton was 224 percent of median and was the 6th highest April discharge in 53 years of record. Snowmelt runoff occurred one month earlier than normal in this part of the State. In the west-central part of the State, mean flow of Buffalo River near Dilworth increased seasonally but was only 16 percent of median, was below the normal range, and was 4th lowest for April since records began in March 1931. In central Minnesota, monthly mean discharge of Crow River at Rockford also increased seasonally but was only 26 percent of median and was below the normal range. In the southwestern part of the State, mean flow of Minnesota River near Jordan increased seasonally but was only 18 percent of median and remained in the below-normal range. (See graph.) Mean



Monthly mean discharge of Minnesota River near Jordan, Minn. (Drainage area, 16,200 sq mi; 42,000 sq km)

flows of Mississippi River at Anoka and Mississippi River at St. Paul also increased but were in the below-normal range.

GROUND-WATER CONDITIONS

Ground-water levels in shallow water-table wells in southern Minnesota began rising after a general 11-month decline, with the exception of a slight temporary recovery in February. However, water levels are still 6 feet below average. In the far north, water

levels rose 0.5 to 2 feet in the shallow aquifers, while in central Minnesota, slight declines were still occurring, and water levels were 3 feet below average.

In Wisconsin, the ground-water table rose during April, except in the area of heavy pumping. Key wells indicate that water levels are in the normal range for April.

In Michigan, ground-water levels rose throughout the State. Levels remained near or below average in most areas.

In Illinois, the key well in glacial drift, at Princeton, Bureau County, was 4.5 feet above average. A new alltime high was reached at Princeton in 37 years of record.

In Indiana, ground-water levels rose continuously during the month and by the end of the month had reached normal levels for April.

In Ohio, ground-water levels rose in key wells, and were about normal for April.

MIDCONTINENT

[Manitoba and Saskatchewan; Arkansas, Iowa, Kansas, Louisiana, Missouri, Nebraska, North Dakota, Oklahoma, South Dakota, and Texas]

Streamflow generally increased in Saskatchewan and South Dakota, decreased in Kansas and Oklahoma, and was variable elsewhere in the region. Monthly mean flows remained below the normal range at all index stations in Saskatchewan, Arkansas, Kansas, Nebraska, and South Dakota, and were lowest of record for April in parts of Louisiana and Nebraska. Daily mean flows also were lowest of record in parts of Louisiana. Below-normal flows have persisted in parts of Kansas for 10 months, in parts of Arkansas and Texas for 6 months, and in parts of Louisiana for 5 months. Flooding occurred in Texas.

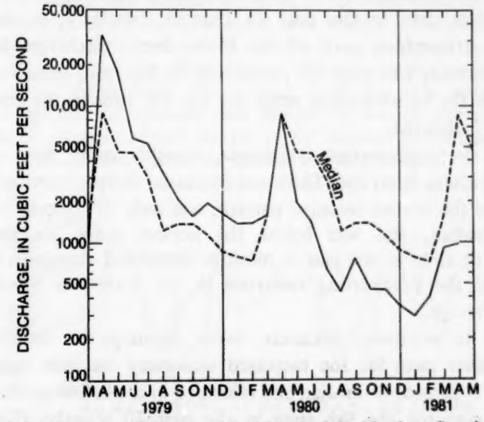
Ground-water levels rose in North Dakota and Nebraska, and declined in Kansas and Texas; trends were mixed in other States. Levels were below average in Nebraska, Kansas, Arkansas, and Louisiana, and were generally above and below average in other States. New lows for the month of April were reached in Nebraska, Kansas, Arkansas, Louisiana, and Texas.

STREAMFLOW CONDITIONS

In northeastern Nebraska, the monthly mean discharge of 512 cfs in Elkhorn River at Waterloo (drainage area, 6,900 square miles) was lowest for April in 61 years of record, and was below the normal range for the 9th time in the past 10 months. Also, the daily mean discharge of 416 cfs at Waterloo on April 20 was equal to the record-low daily mean flow for the month, observed in 1934. In the northwestern part of the State, mean flow of Niobrara River above Box Butte Reservoir decreased seasonally, was only 46 percent of median, and was in the below-normal range for the 4th time in the past 5 months. Flows also were below-normal in north-central Nebraska as well as in the North Platte River basin in the western part of the State. Monthly mean flows in unregulated streams in the Republican River basin in southwestern Nebraska were reported to have been 140 percent of normal in the extreme southwestern part of that basin and 90 percent of normal in the other parts. At monthend, the National Weather Service reported severe drought conditions in northeastern, north-central, and extreme southeastern parts of the State.

In eastern South Dakota, monthly mean flow of Big Sioux River, as measured at Akron, Iowa, on the South Dakota-Iowa boundary, increased contrary to the normal seasonal pattern, but remained in the below-normal range and was only 28 percent of median. In the central part of the State, monthly mean flow in Bad River near Fort Pierre was 1 percent of median and remained below the normal range.

In southwestern North Dakota, the mean discharge of 24 cfs in Cannonball River at Breien (drainage area, 4,100 square miles) was second lowest for April since records began in August 1934, was below the normal range for the second consecutive month, and was only 8 percent of the April median flow. In the eastern part of the State, and the adjacent area of Minnesota, the mean flow of 981 cfs in Red River of the North at Grand Forks (drainage area, 30,100 square miles) was second lowest for April since records began in April 1882, was only 11 percent of the median for the month, and was below the normal range for the 11th time in the past 12 months. (See graph.) At



Monthly mean discharge of Red River of the North at Grand Forks, N. Dak. (Drainage area, 30,100 sq mi; 79,000 sq km)

monthend the National Weather Service reported that drought conditions existed in approximately all of the southern half of the State, where less than one inch of precipitation has been observed since January 1 at many reporting stations.

In southeastern Saskatchewan, monthly mean discharge of Qu'Appelle River near Lumsden increased seasonally but was only 11 percent of median and remained below the normal range.

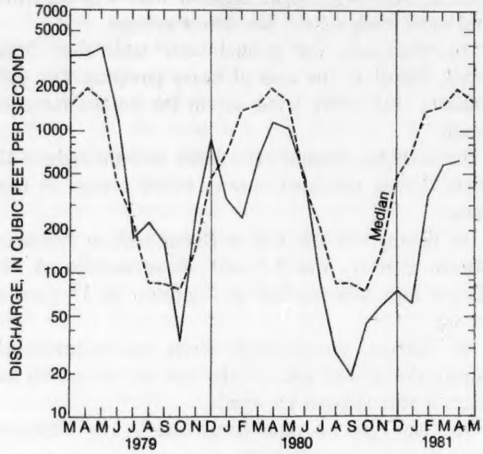
In eastern Iowa, monthly mean flow of Cedar River at Cedar Rapids increased, contrary to the normal seasonal pattern, as a result of runoff from rains near midmonth, and was in the normal range. In the north-central part of the State, mean discharge of Des Moines River at Fort Dodge also increased, but remained in the below-normal range and was only 21 percent of median. In southwestern Iowa, monthly mean flow of Nishnabotna River above Hamburg decreased but also remained in the below-normal range.

By contrast, in the adjacent area of northwestern Missouri, monthly mean discharge of Grand River near Gallatin increased sharply, as a result of runoff from rains near monthend, and was in the normal range, following 2 months of below-normal flow. In southern Missouri, mean flow of Gasconade River at Jerome decreased, was only 23 percent of median, and remained below the normal range for the 10th time in the past 12 months.

In Kansas, streamflow generally decreased and remained below the normal range. For example, in the northeastern part of the State, mean discharge of Little Blue River near Barnes decreased slightly, was only 40 percent of median, and remained below the normal range for the 10th consecutive month. In southwestern Kansas, monthly mean flow of Arkansas River at Arkansas City also decreased slightly, was only 29 percent of median, and was below the normal range for the 10th time in the past 11 months. Similarly, in the northwestern part of the State, mean discharge decreased, was only 25 percent of median, and remained in the below-normal range for the 9th time in the past 11 months.

In southwestern Oklahoma, monthly mean flow of Washita River near Durwood decreased sharply, contrary to the normal seasonal pattern, was only 27 percent of median, and was below the normal range for the 7th time in the past 9 months. Monthend storage in 6 of the 8 reporting reservoirs in the State was below average.

In northern Arkansas, mean discharge of Buffalo River near St. Joe increased seasonally but was only 31 percent of median and remained in the below-normal range for the 9th time in the past 10 months. (See graph.) In the southern part of the State, mean flow of Saline River near Rye also decreased seasonally, and



Monthly mean discharge of Buffalo River near St. Joe, Ark. (Drainage area, 829 sq mi; 2,147 sq km)

remained below the normal range for the 4th consecutive month.

In northwestern Louisiana, monthly mean discharge of Saline Bayou near Lucky (drainage area, 154 square miles) decreased seasonally, and the monthly mean flow of 45.9 cfs, together with the daily mean of 12 cfs on April 18, were lowest for the month since records began in June 1940. Also in northern Louisiana, monthly mean flows in Bayou Toro near Toro, Paw Paw Bayou near Greenwood, Big Creek at Pollock, and Red River at Alexandria, were 2d lowest of record for each of those sites. In the southern part of the State, mean flow of Amite River near Denham Springs decreased seasonally and was below the normal range, and mean flow of Calcasieu River near Oberlin decreased sharply, was only 9 percent of median and remained in the below-normal range for the 5th consecutive month.

In eastern Texas, monthly mean flow of Neches River near Rockland decreased, in contrast to the normal seasonal pattern, was only 12 percent of median, and remained below the normal range for the 6th consecutive month. Also in the eastern part of the State, mean flow of North Bosque River near Clifton remained unchanged from March, was only 12 percent of the April median discharge, and was below the normal range. In south-central Texas, monthly mean flow of Guadalupe River near Spring Branch decreased slightly but was 3 times median, and remained in the above-normal range. Monthend records for 38 reservoirs showed that storage increased in 20, decreased in 16,

and remained the same as at end of March in 2. The National Weather Service reported minor to moderate flooding along streams in the southern and western parts of the State.

GROUND-WATER CONDITIONS

In North Dakota, ground-water levels rose slightly in the eastern part of the State, but remained below normal in all but the north-central part of the State.

In Nebraska, ground-water levels rose in most deep observation wells and were slightly higher in most shallow water-table wells. Levels continued to be below long-term averages with a key well in the alluvial sand and gravel of the Platte River Valley near Ashland reaching a new low for the month in 48 years of record for the second consecutive month.

In Iowa, ground-water levels in shallow wells rose in all areas except the western edge of the State. Levels were above average in most areas, but remained below average in the extreme northeastern and southwestern parts of the State.

In Kansas, levels declined in key wells in Douglas, Sedgwick, Harvey, and Thomas Counties, and continued below average. The level in the well at the Kansas Agricultural Experiment Station in Thomas County again reached a new low for the month in 33 years of record.

In Arkansas, the level in the deep Sparta Sand aquifer rose 3.5 feet but was 24 feet below the average for April. In the industrial Sparta Sand aquifer of central and south Arkansas, the level in the key well at Pine Bluff rose 1.5 feet, but was still a record low for April in 22 years of record. The level at Pine Bluff was about 38 feet below average. The level at the Eldorado well fell 2.4 feet from last month, and remained below average.

In Louisiana, trends were mixed. Water levels in wells completed in the shallowest and deepest major aquifers of the Baton Rouge area have risen sharply since the beginning of the year. Water levels have declined in wells in the "1,500-foot" and "2,000-foot" sands. In the eastern Florida Parishes, water levels in most observation wells have risen since January; in Tangipahoa Parish and further west, levels have declined. In the New Orleans area, water levels have risen in wells in the major aquifers since January. In northern and central Louisiana, water levels in most wells in the alluvial and terrace aquifers are still below normal. Long-term declining trends continued in wells in Miocene aquifers and the Sparta Sand. Water levels in wells in the Chicot aquifer in most of southwestern Louisiana were lower this spring than in the springs of 1979 and 1980. In the rice-growing area in the southwestern part of the State, water levels were generally lower. Levels declined in wells in the Evangeline aquifer in the Eunice and Opelousas areas, and have had record-low levels each month for about a year.

In Texas, ground-water levels in key wells were above average in the Edwards aquifer at Austin, but below average in the Edwards aquifer at San Antonio, in the Evangeline aquifer at Houston, and in the bolson deposits at El Paso. Water levels fell at Austin, San Antonio, Houston, and El Paso. New April lows were recorded at Houston and El Paso.

WEST

[Alberta and British Columbia; Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming]

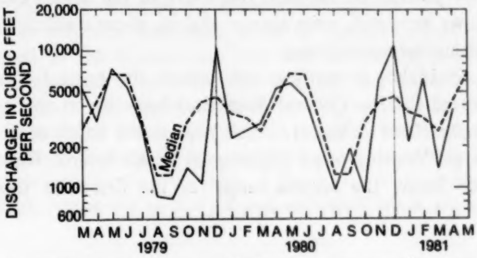
Streamflow was variable in Arizona, California, and New Mexico, and generally increased seasonally elsewhere in the region. Monthly mean flows remained in the below-normal range in parts of Arizona, California, Colorado, Montana, Nevada, New Mexico, Utah, Washington, and Wyoming, and decreased into that range in parts of Idaho. Flows remained in the above-normal range in parts of New Mexico, and increased into that range in parts of Oregon, Utah, and Washington. Mean flows were lowest of record for the month in parts of New Mexico and Wyoming.

Ground-water levels rose in Washington, and declined in Arizona and New Mexico. Trends were mixed in Idaho, Montana, southern California, Nevada, and Utah. Levels were below average in Idaho, Arizona, and New Mexico, and generally above and below average in other States. A new alltime high level was again reached in southern California, and a new alltime low was again noted in Idaho and Arizona. New April lows were reached in Idaho, Arizona, and Utah, and a new April high was reached in Utah.

STREAMFLOW CONDITIONS

In Alberta and British Columbia, streamflow increased seasonally at all index stations, was within the normal range, and slightly above the median flows for April.

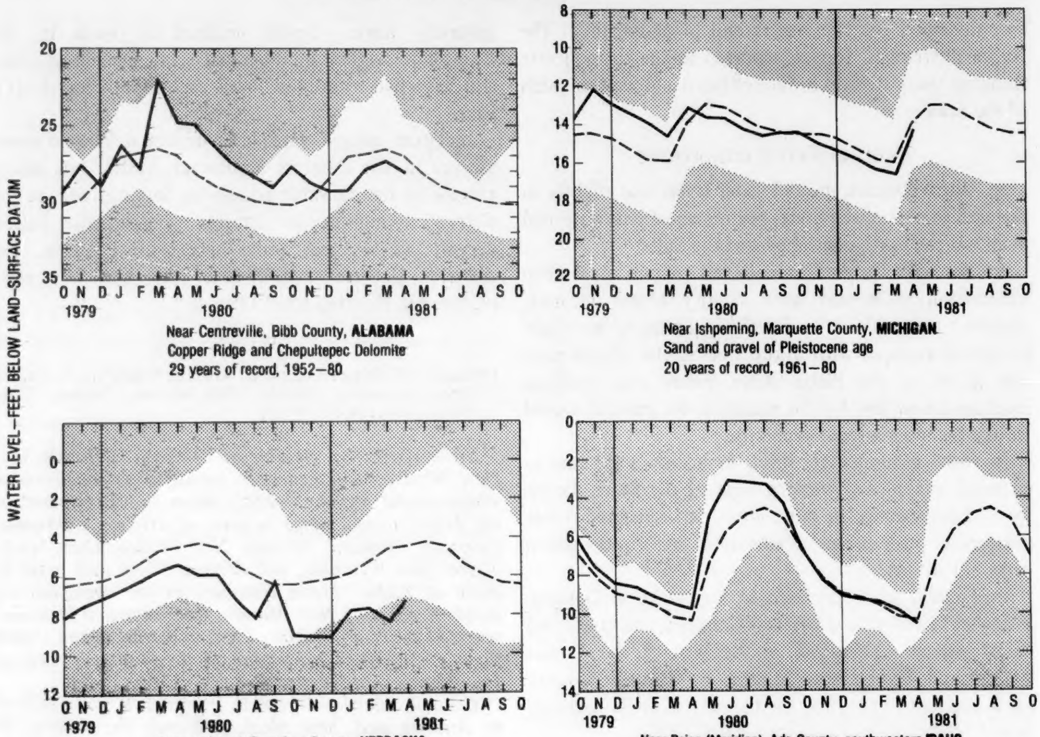
In northwestern Washington, where monthly mean flow of Skykomish River near Gold Bar was only 53 percent of median and lowest of record during March, flow increased sharply to 87 percent of median in April and was within the normal range. (See graph.) In



Monthly mean discharge of Skykomish River near Gold Bar, Wash. (Drainage area, 535 sq mi; 1,386 sq km)

MONTH-END GROUND-WATER LEVELS IN KEY WELLS

UNSHADED AREA INDICATES RANGE BETWEEN HIGHEST AND LOWEST RECORD FOR THE MONTH
DOTTED LINE INDICATES AVERAGE OF MONTHLY LEVELS, IN PREVIOUS YEARS
HEAVY LINE INDICATES LEVEL FOR CURRENT PERIOD



Near Centreville, Bibb County, **ALABAMA**
Copper Ridge and Chepultepec Dolomite
29 years of record, 1952–80

Near Ishpeming, Marquette County, **MICHIGAN**
Sand and gravel of Pleistocene age
20 years of record, 1961–80

Near Ashland, Saunders County, **NEBRASKA**
Sand and gravel deposits of Pleistocene age
48 years of record, 1933–80

Near Boise (Meridian), Ada County, southwestern **IDAHO**
Quaternary sand and gravel
47 years of record, 1934–80

the eastern part of the State, mean flow of Spokane River at Spokane also increased seasonally, but remained in the below-normal range and was only 62 percent of median. In the southwestern part of the State, monthly mean discharge of Chehalis River near Grand Mound increased sharply and was above the normal range for the first time since December 1980.

Similarly, in northwestern Oregon, where mean flow in Wilson River near Tillamook was below the normal range and only 34 percent of median in March, flow increased sharply as a result of runoff from rains during the month, and was above the normal range at 144 percent of median. Elsewhere in the State, mean flows increased, were near or slightly above median, but within the normal range.

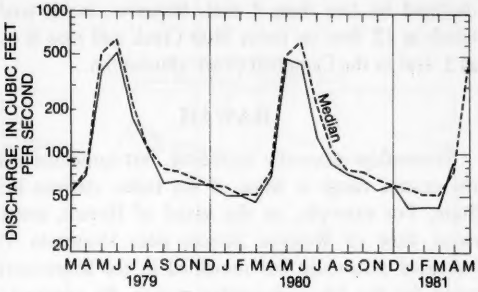
In Idaho, streamflow was within the normal range except for the Coeur d'Alene and Boise Rivers and the Snake River at Weiser, which were in the below-normal range. Monthly mean discharge at Snake River at Weiser was below the normal range for the first time since October 1980. Reservoir storage was generally above average.

In north-coastal California, monthly mean discharge of Smith River near Crescent City decreased seasonally and remained in the below-normal range for the 2d consecutive month. In the northern Sierra Nevada west slope, monthly mean discharge of North Fork American River at North Fork Dam increased seasonally to 52 percent of median but also remained in the below-normal range. In the southern Sierra Nevada west slope, monthly mean flow of Kings River above North Fork, near Trimmer, was above median and, together with Arroyo Seco near Pasadena, in southern California, were within the normal range. Combined contents of 10 index reservoirs in northern and central California were 113 percent of average and 104 percent of the contents one year ago.

In north-central Nevada, monthly mean discharge in Humboldt River at Palisade increased seasonally but was only 29 percent of median and remained in the below-normal range for the 2d consecutive month.

In south-central Montana, monthly mean discharge of Yellowstone River at Billings increased seasonally but was only 77 percent of median and remained in the below-normal range. Elsewhere in the State, monthly mean flows at index stations increased seasonally and were within the normal range. Severe drought conditions were reported in the eastern part of the State by the National Weather Service.

In northern Wyoming, monthly mean discharge of Tongue River near Dayton increased seasonally as a result of runoff from an early snow melt and mean flow at that site was within the normal range at 116 percent of median. (See graph). By contrast, in the southern part



Monthly mean discharge of Tongue River near Dayton, Wyo. (Drainage area, 204 sq mi; 528 sq km)

of the State, the monthly mean flow of 563 cfs in North Platte River above Seminoe Reservoir, near Sinclair (drainage area, 8,134 square miles) was lowest for April in period of record that began in July 1939.

In Utah, streamflow increased seasonally and was within the normal range except in the Green River, San Juan River, and Colorado River basins where minimum releases from reservoir storage held monthly mean flows in the below-normal range. In the southwestern part of the State, mean flow of Beaver River near Beaver increased sharply to 191 percent of median and was above the normal range.

Contents of the Colorado River Storage Project decreased 99,690 acre-feet during the month.

East of the Continental Divide in central Colorado, monthly mean flow in Bear Creek at Morrison continued to increase seasonally but was below the normal range for the 3d time in the past 4 months. In the southwestern part of the State, monthly mean discharge in Animas River at Durango also continued to increase seasonally but remained in the below-normal range for the 4th consecutive month. Elsewhere in the State, mean flows increased seasonally and were below median but within the normal range.

In northern New Mexico, the monthly mean discharge of 243 cfs and the daily mean of 211 cfs on April 10, 11 at Rio Grande below Taos Junction Bridge, near Taos (drainage area, 9,730 square miles), were lowest for the month in 56 years of record. In the north-central part of the State, mean flow of Pecos River near Pecos increased seasonally but remained in the below-normal range for the 2d consecutive month and was less than ½ median. By contrast, in southeastern New Mexico, monthly mean discharge in Delaware River near Red Bluff decreased seasonally to 294 percent of median but remained in the above-normal range for the 6th consecutive month.

In southern Arizona, mean flow in San Pedro River at Charleston decreased seasonally to 60 percent of median and remained in the below-normal range for the 10th consecutive month. In the northeastern part of the State, monthly mean discharge of Little Colorado River near Cameron increased seasonally to 11 percent of the median flow for April but remained in the below-normal range for the 7th consecutive month. Elsewhere in the State, mean flows at index stations remained in the normal range.

GROUND-WATER CONDITIONS

In Washington, the artesian ground-water level in the key well in Tacoma, in the western part of the State, rose and was about 2.6 feet above average. The level in the key well in Spokane Valley, in eastern Washington, rose slightly but continued below average.

In Idaho, the level in the well penetrating the sand and gravel aquifer in the Boise Valley was slightly below average. Water levels in the key wells representative of the Snake River Plain aquifer reached the same month-end low as last year near Atomic City, reached a new April low near Rupert in 30 years of record, reached a new alltime low near Eden in 23 years of record, and were 5.5 feet below average in the well near Gooding. The level in the water-table well representative of the alluvial aquifer underlying the Rathdrum Prairie, in northern Idaho, rose but continued below average by more than 6 feet.

In Montana, levels in the key water-table wells rose at Missoula but declined at Hamilton and continued to be nearly 1 foot below normal at both localities.

In southern California, in Santa Barbara County, the level in the non-artesian key well in the Santa Maria Valley, which reached an alltime high last month, rose 0.5 foot and again reached an alltime high level in 23 years of record. The level in the other two key wells in Santa Barbara fell but remained above average. In Los Angeles County, the level of the key well at Baldwin Park continued to decline and remained below average.

In Nevada, the level in the key well in Las Vegas Valley fell, but rose in the key wells in Paradise and Steptoe Valleys. The level was below average in Las Vegas Valley, but above average in Paradise and Steptoe Valleys.

In Utah, levels declined 12.5 feet in the Flowell area and 5 feet in the Holladay area, and remained unchanged in the Logan area. Levels near Flowell and Holladay were 15 feet below average, but were above average in the Blanding and Logan areas. A new month high was again set near Blanding in 20 years of record, and a new month low was again set at Holladay in 32 years of record.

In Arizona, water levels declined from 1 to 6.8 feet in 4 key wells during the month of April. The water level in one well reached a new April low; one well reached an alltime low.

In New Mexico, water levels in key wells continued below average. Roswell basin wells, in the southeastern part of the State, declined more than 6 feet. Levels in the artesian aquifer are 1.5 feet lower than April of last year. Other areas of the State show very small changes from last year. Levels in the 4 key wells remain below average.

ALASKA

In Alaska, snowmelt runoff from lower elevations resulted in increased flow in some streams during April. For example, in the interior, mean flow of Tanana River at Nenana (drainage area, 25,600 square miles) increased, remained above the normal range for the 6th consecutive month, and the monthly discharge of 10,880 cfs was highest for April since records began in 1963. In south-central Alaska, monthly mean flow of Little Susitna River near Palmer increased seasonally and was in the above-normal range for the first time since September 1980. In the south-coastal basin of Kenai River, monthly mean discharge at Cooper Landing decreased from the record-high flow of March but remained in the above-normal range for the 4th consecutive month. In southeastern Alaska, where monthly mean flow of Gold Creek at Juneau was above the normal range in January, February, and March, mean discharge decreased in April, contrary to the normal seasonal pattern, and was in the normal range.

Ground-water levels in wells tapping both confined and unconfined aquifers in the Anchorage area generally declined by less than 2 feet. However, levels rose as much as 12 feet on lower Ship Creek and rose as much as 2 feet in the Campbell Creek alluvial fan.

HAWAII

Streamflow generally increased, but remained below the normal range at some of the index stations in the State. For example, on the island of Hawaii, monthly mean flow of Waiakea Stream near Mountain View increased seasonally but remained in the below-normal range for the 5th consecutive month. By contrast, on the island of Maui, mean discharge in Honopou Stream near Huelo decreased, contrary to the normal seasonal pattern, was only 16 percent of median, and remained below the normal range for the 5th consecutive month. On the islands of Kauai and Oahu, the monthly mean flows of East Branch of North Fork Wailua River near Lihue and Kalihi Stream near Honolulu, respectively, increased from the below-normal range into the normal range but remained below the April median discharges for those index stations.

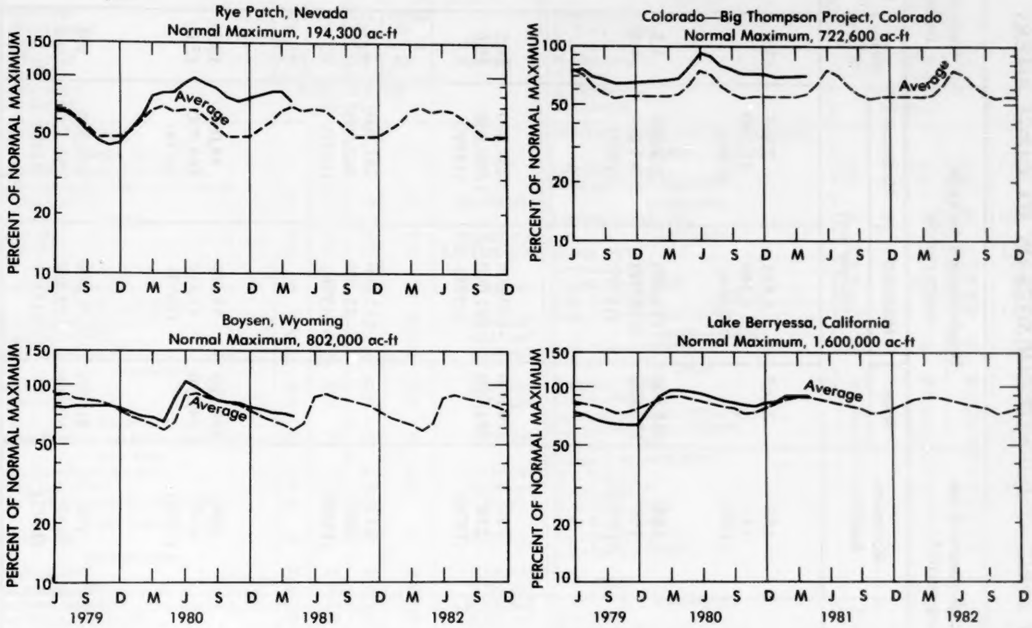
On Guam, Mariana Islands, monthly mean flow of Ylig River near Yona increased contrary to the normal seasonal pattern, but remained in the normal range.

METRIC EQUIVALENTS OF UNITS USED IN THE WATER RESOURCES REVIEW

(Round-number conversions, to nearest four significant figures)

1 foot = 0.3048 meter 1 mile = 1.609 kilometers
1 acre = 0.4047 hectare = 4,047 square meters
1 square mile (sq mi) = 259 hectares = 2.59 square kilometers (sq km)
1 acre-foot (ac-ft) = 1,233 cubic meters
1 million cubic feet (mcf) = 28,320 cubic meters
1 cubic foot per second (cfs) = 0.02832 cubic meters per second = 1.699 cubic meters per minute
1 second-foot-day (cfsd) = 2,447 cubic meters
1 million gallons (mg) = 3,785 cubic meters = 3.785 million liters
1 million gallons per day (mgd) = 694.4 gallons per minute (gpm) = 2.629 cubic meters per minute = 3,785 cubic meters per day

USABLE CONTENTS OF SELECTED RESERVOIRS AND RESERVOIR SYSTEMS, JUNE 1979 TO APRIL 1981



Near- or above-average contents continued to characterize most reservoirs in the West during April, including all the reservoirs shown on the above graphs.

DISSOLVED SOLIDS AND WATER TEMPERATURES FOR APRIL ON SIX LARGE RIVERS

The table on page 16 shows dissolved-solids and temperature data for April at six stream-sampling sites that are part of the National Stream Quality Accounting Network (NASQAN). NASQAN, as established by the U.S. Department of the Interior, Geological Survey, is designed to describe the water quality of the Nation's streams and rivers on a systematic and continuing basis, so as to meet many of the information needs of those involved in national or regional water-quality planning and management.

"Dissolved solids," as described in several columns of the table, are minerals dissolved in water and usually consist predominantly of silica and ions of calcium, magnesium, sodium, potassium, carbonate, bicarbonate, sulfate, chloride, and nitrate. These same minerals are among the most common components of the Earth's solid rocks and minerals, but gradually erode and at least partly dissolve as a part of natural weathering processes. Collectively these and other dissolved minerals constitute the dissolved-solids concentration expressed in milligrams per liter (mg/L) or the generally equivalent expression, parts per million (parts of dissolved matter in one million parts of water, by weight). Values of dissolved solids are convenient for comparing the quality of water from one time to another and from one place to another. Most drinking water contains between 50 and 500 mg/L of dissolved solids.

"Dissolved-solids discharge," expressed in tons per day, represents the total daily amount of dissolved minerals carried by the stream and is calculated by multiplying the dissolved-solids concentration (in mg/L) by the stream discharge (in cfs; times a unit conversion factor of .0027). Even though dissolved-solids *concentrations* are generally higher during periods of low streamflow than of high streamflow, the highest dissolved-solids *discharges* occur during periods of high streamflow because the total quantities of water, and therefore total load of dissolved minerals, are so much greater than at times of low flow.

DISSOLVED SOLIDS AND WATER TEMPERATURES FOR APRIL AT DOWNSTREAM SITES ON SIX LARGE RIVERS

Station number	Station name	April data of following calendar years	Stream discharge during month	Dissolved-solids concentration during month[a]		Dissolved-solids discharge during month[a]			Water temperature during month[b]		
			Mean (cfs)	Minimum (mg/L)	Maximum (mg/L)	Mean	Minimum	Maximum	Mean, in °C	Mini-mum, in °C	Maxi-mum, in °C
						(tons per day)					
	NORTHEAST										
01463500	Delaware River at	1981	7,828	91	124	2,163	1,438	2,845	13.5	11.0	15.5
	Trenton, N.J.	1945–80	21,930	46	121	......	1,240	12,300	.....	3.0	22.5
	(Morrisville, Pa.)	(Extreme yr)		(1962)	(1978)		(1966)	(1960)			
			[c]21,180								
04264331	St. Lawrence River at	1981	260,000	165	166	116,000	111,000	122,000	5.5	3.0	6.5
	Cornwall, Ontario, near	1976–80	287,400	164	168	129,000	118,000	146,000	4.0	0.5	6.5
	Massena, N.Y.	(Extreme yr)		(1977)	(1976)		(1977)	(1976)			
	median streamflow at		[c]250,500								
	Ogdensburg, N.Y.										
	SOUTHEAST										
07289000	Mississippi River at	1981	436,300	215	250	276,000	180,000	397,000	16.5	11.0	19.0
	Vicksburg, Miss.	1976–80	1,086,000	155	238	581,000	291,000	1,030,000	15.0	7.0	20.0
		(Extreme yr)		(1977)	(1976)		(1976)	(1979)			
			[c]981,200								
	WESTERN GREAT LAKES REGION										
03612500	Ohio River at lock and dam	1981	363,000	168	217	......	115,000	261,000	.....	11.5	18.0
	53, near Grand Chain, Ill.	1955–80	443,300	117	282	......	22,400	462,000	.....	6.5	19.0
	(25 miles west of Paducah,	(Extreme yr)		(1957)	(1969)		(1976)	(1975)			
	Ky.; streamflow station		[c]450,800								
	at Metropolis, Ill.)										
	MIDCONTINENT										
06934500	Missouri River at Hermann,	1981	52,600	397	504	648,000	55,000	88,000	18.0	14.0	22.5
	Mo. (60 miles west of St.	1976–80	120,500	157	433	94,100	41,400	168,000	13.0	6.0	20.0
	Louis, Mo.)	(Extreme yr)		(1979)	(1976)		(1977)	(1978)			
			[c]95,600								
	WEST										
14128910	Columbia River at	1981	155,000	95	102	41,900	31,300	48,900	9.0	8.0	11.0
	Warrendale, Oreg.	1976–80	180,400	85	127	52,700	22,300	90,500	9.0	7.0	12.5
	(streamflow station	(Extreme yr)		(1976)	(1977)		(1977)	(1976)			
	at The Dalles, Oreg.)		c190,600								

[a]Dissolved-solids concentrations when not analyzed directly, are calculated on basis of measurements of specific conductance.
[b]To convert °C to °F: [(1.8 X °C) + 32] = °F.
[c]Median of monthly values for 30-year reference period, water years 1941–70, for comparison with data for current month.

Provisional data; subject to revision

USABLE CONTENTS OF SELECTED RESERVOIRS NEAR END OF APRIL 1981

[Contents are expressed in percent of reservoir capacity. The usable storage capacity of each reservoir is shown in the column headed "Normal maximum."]

Reservoir Principal uses: F–Flood control I–Irrigation M–Municipal P–Power R–Recreation W–Industrial	End of Mar. 1981	End of Apr. 1981	End of Apr. 1980	Average for end of Apr.	Normal maximum
	Percent of normal maximum				
NORTHEAST REGION					
NOVA SCOTIA					
Rossignol, Mulgrave, Falls Lake, St. Margaret's Bay, Black, and Ponhook Reservoirs (P)	77	83	75	76	226,300 (a)
QUEBEC					
Allard (P)	78	92	76	79	280,600 ac-ft
Gouin (P)	69	84	67	46	6,954,000 ac-ft
MAINE					
Seven reservoir systems (MP)	58	82	60	66	178,500 mcf
NEW HAMPSHIRE					
First Connecticut Lake (P)	45	75	62	49	3,330 mcf
Lake Francis (FPR)	52	75	66	54	4,326 mcf
Lake Winnipesaukee (PR)	84	100	100	97	7,220 mcf
VERMONT					
Harriman (P)	39	49	87	78	5,060 mcf
Somerset (P)	79	88	72	74	2,500 mcf
MASSACHUSETTS					
Cobble Mountain and Borden Brook (MP)	86	88	92	89	3,394 mcf
NEW YORK					
Great Sacandaga Lake (FPR)	82	97	97	91	34,270 mcf
Indian Lake (FMP)	60	84	82	91	4,500 mcf
New York City reservoir system (MW)	66	70	100	.....	547,500 mg
NEW JERSEY					
Wanaque (M)	62	76	101	94	27,730 mg
PENNSYLVANIA					
Allegheny (FPR)	35	45	38	45	51,400 mcf
Pymatuning (FMR)	93	98	98	103	8,191 mcf
Raystown Lake (FR)	55	57	68	56	33,190 mcf
Lake Wallenpaupack (PR)	65	79	82	79	6,875 mcf
MARYLAND					
Baltimore municipal system (M)	77	81	100	95	85,340 mg
SOUTHEAST REGION					
NORTH CAROLINA					
Bridgewater (Lake James) (P)	85	88	100	93	12,580 mcf
Narrows (Badin Lake) (P)	78	88	97	101	5,616 mcf
High Rock Lake (P)	43	69	91	85	10,230 mcf
SOUTH CAROLINA					
Lake Murray (P)	87	89	94	82	70,300 mcf
Lakes Marion and Moultrie (P)	77	96	90	81	81,100 mcf
SOUTH CAROLINA--GEORGIA					
Clark Hill (FP)	64	60	81	76	75,360 mcf
GEORGIA					
Burton (PR)	85	95	96	92	104,000 ac-ft
Sinclair (MPR)	90	89	92	92	214,000 ac-ft
Lake Sidney Lanier (FMPR)	51	53	69	64	1,686,000 ac-ft
ALABAMA					
Lake Martin (P)	80	94	99	95	1,373,000 ac-ft
TENNESSEE VALLEY					
Clinch Projects: Norris and Melton Hill Lakes (FPR)	30	46	68	62	1,156,000 cfsd
Douglas Lake (FPR)	30	57	77	62	703,100 cfsd
Hiwassee Projects: Chatuge, Nottely, Hiwassee, Apalachia, Blue Ridge, Ocoee 3, and Parksville Lakes (FPR)	59	58	90	79	510,300 cfsd
Holston Projects: South Holston, Watauga, Boone, Fort Patrick Henry, and Cherokee Lakes (FPR)	39	52	71	67	1,452,000 cfsd
Little Tennessee Projects: Nantahala, Thorpe, Fontana, and Chilhowee Lakes (FPR)	40	56	87	78	745,200 cfsd
WESTERN GREAT LAKES REGION					
WISCONSIN					
Chippewa and Flambeau (PR)	51	89	63	70	15,900 mcf
Wisconsin River (21 reservoirs) (PR)	42	83	62	69	17,400 mcf
MINNESOTA					
Mississippi River headwater system (FMR)	21	26	28	31	1,640,000 ac-ft
MIDCONTINENT REGION					
NORTH DAKOTA					
Lake Sakakawea (Garrison) (FIPR)	70	69	81	86	22,700,000 ac-ft
SOUTH DAKOTA					
Angostura (I)	74	73	99	86	127,600 ac-ft
Bell Fourche (I)	46	50	65	71	185,200 ac-ft
Lake Francis Case (FIP)	77	83	75	82	4,834,000 ac-ft
Lake Oahe (FIP)	77	72	86	.....	22,530,000 ac-ft
MIDCONTINENT REGION--Continued					
SOUTH DAKOTA--Continued					
Lake Sharpe (FIP)	102	99	101	100	1,725,000 ac-ft
Lewis and Clarke Lake (FIP)	83	79	76	82	477,000 ac-ft
NEBRASKA					
Lake McConaughy (IP)	82	84	84	78	1,948,000 ac-ft
OKLAHOMA					
Eufaula (FPR)	78	96	82	93	2,378,000 ac-ft
Keystone (FPR)	86	87	95	110	661,000 ac-ft
Tenkiller Ferry (FPR)	88	92	101	98	628,200 ac-ft
Lake Altus (FIMR)	21	22	72	58	133,000 ac-ft
Lake O'The Cherokees (FPR)	78	79	97	92	1,492,000 ac-ft
OKLAHOMA--TEXAS					
Lake Texoma (FMPRW)	93	95	82	92	2,722,000 ac-ft
TEXAS					
Bridgeport (IMW)	32	34	30	49	386,400 ac-ft
Canyon (FMR)	95	99	93	75	385,600 ac-ft
International Amistad (FIMPW)	90	95	90	82	3,497,000 ac-ft
International Falcon (FIMPW)	91	99	76	69	2,668,000 ac-ft
Livingston (IMW)	96	98	101	84	1,788,000 ac-ft
Possum Kingdom (IMPRW)	88	92	84	96	570,200 ac-ft
Red Bluff (PI)	23	24	24	26	307,000 ac-ft
Toledo Bend (P)	83	83	100	89	4,472,000 ac-ft
Twin Buttes (FIM)	47	51	36	30	177,800 ac-ft
Lake Kemp (IMW)	50	52	49	85	268,000 ac-ft
Lake Meredith (FMW)	17	17	27	36	821,300 ac-ft
Lake Travis (FIMPRW)	99	99	87	80	1,144,000 ac-ft
THE WEST					
WASHINGTON					
Ross (PR)	80	65	23	26	1,052,000 ac-ft
Franklin D. Roosevelt Lake (IP)	86	55	41	48	5,022,000 ac-ft
Lake Chelan (PR)	59	61	26	39	676,100 ac-ft
Lake Cushman	86	88	101	88	359,500 ac-ft
Lake Merwin (P)	101	101	97	101	245,600 ac-ft
IDAHO					
Boise River (4 reservoirs) (FIP)	87	95	85	71	1,235,000 ac-ft
Coeur d'Alene Lake (P)	76	110	110	126	238,500 ac-ft
Pend Oreille Lake (FP)	60	73	47	56	1,561,000 ac-ft
IDAHO--WYOMING					
Upper Snake River (8 reservoirs) (MP)	91	92	85	75	4,401,000 ac-ft
WYOMING					
Boysen (FIP)	72	70	65	59	802,000 ac-ft
Buffalo Bill (IP)	78	77	54	60	421,300 ac-ft
Keyhole (F)	53	49	75	51	190,400 ac-ft
Pathfinder, Seminoe, Alcova, Kortes, Glendo, and Guernsey Reservoirs (I)	63	64	53	51	3,056,000 ac-ft
COLORADO					
John Martin (FIR)	21	17	13	14	364,400 ac-ft
Taylor Park (IR)	47	51	49	56	106,200 ac-ft
Colorado–Big Thompson project (I)	70	71	68	56	722,600 ac-ft
COLORADO RIVER STORAGE PROJECT					
Lake Powell; Flaming Gorge, Fontenelle, Navajo, and Blue Mesa Reservoirs (IFPR)	83	83	81	.....	31,620,000 ac-ft
UTAH--IDAHO					
Bear Lake (IPR)	75	75	79	63	1,421,000 ac-ft
CALIFORNIA					
Folsom (FIP)	79	93	72	73	1,000,000 ac-ft
Hetch Hetchy (MP)	31	46	58	37	360,400 ac-ft
Isabella (FIR)	42	46	65	31	568,100 ac-ft
Pine Flat (FI)	77	86	62	59	1,001,000 ac-ft
Clair Engle Lake (Lewiston) (P)	86	91	89	86	2,438,000 ac-ft
Lake Almanor (P)	83	84	85	57	1,036,000 ac-ft
Lake Berryessa (FIMW)	89	89	96	88	1,600,000 ac-ft
Millerton Lake (FI)	64	79	51	67	503,200 ac-ft
Shasta Lake (FIPR)	98	99	94	90	4,377,000 ac-ft
CALIFORNIA--NEVADA					
Lake Tahoe (IPR)	48	52	47	59	744,600 ac-ft
NEVADA					
Rye Patch (I)	86	76	84	71	194,300 ac-ft
ARIZONA--NEVADA					
Lake Mead and Lake Mohave (FIMP)	89	87	88	66	27,970,000 ac-ft
ARIZONA					
San Carlos (IP)	57	52	92	21	1,073,000 ac-ft
Salt and Verde River system (IMPR)	72	73	97	52	2,073,000 ac-ft
NEW MEXICO					
Conchas (FIR)	35	31	44	81	330,100 ac-ft
Elephant Butte and Caballo (FIPR)	53	47	41	28	2,453,000 ac-ft

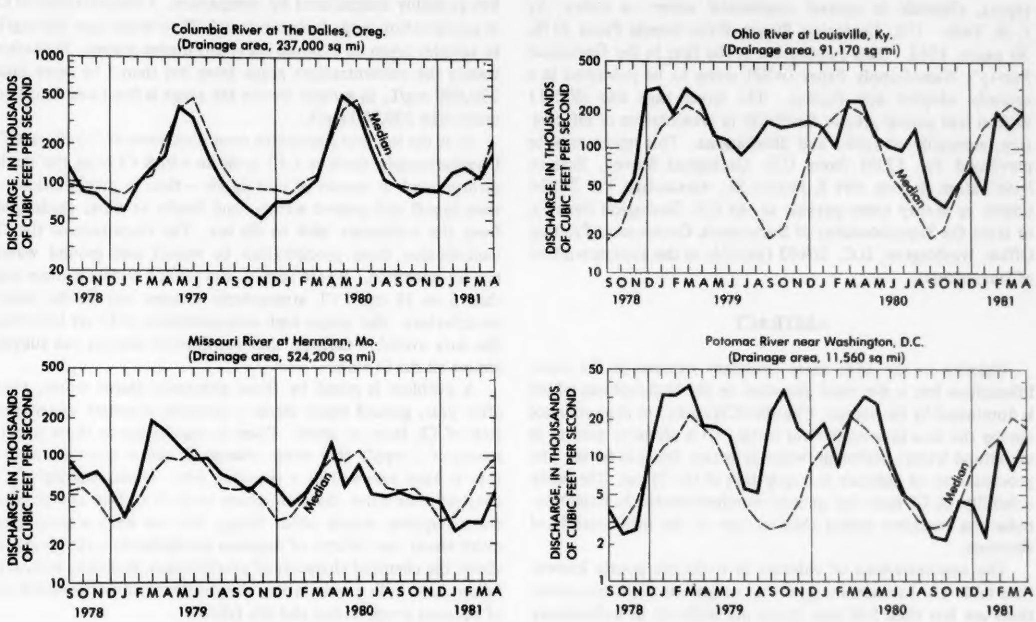
[a]Thousands of kilowatt-hours (the potential electric power that could be generated by the volume of water in storage).

FLOW OF LARGE RIVERS DURING APRIL 1981

Station number*	Stream and place of determination	Drainage area (square miles)	Mean annual discharge through September 1975 (cfs)	April 1981 Monthly discharge (cfs)	Percent of median monthly discharge, 1941–70	Charge in discharge from previous month (percent)	Discharge near end of month (cfs)	(mgd)	Date
1–0140	St. John River below Fish River at Fort Kent, Maine	5,690	9,549	29,900	144	+394	18,000	11,600	30
1–3185	Hudson River at Hadley, N.Y	1,664	2,853	4,110	48	+35	2,500	1,620	30
1–3575	Mohawk River at Cohoes, N.Y	3,456	5,630	4,680	36	-2	3,400	2,200	30
1–4635	Delaware River at Trenton, N.J	6,780	11,630	7,841	37	+5	8,220	5,310	29
1–5705	Susquehanna River at Harrisburg, Pa	24,100	34,200	31,730	46	+3	40,000	26,000	30
1–6465	Potomac River near Washington, D.C	11,560	[1] 11,190	13,850	80	+76	8,200	5,300	30
2–1055	Cape Fear River at William O. Huske Lock near Tarheel, N.C	4,810	5,007	1,730	30	-33	980	630	30
2–1310	Pee Dee River at Peedee, S.C	8,830	9,657	3,620	28	-30	1,100	710	28
2–2260	Altamaha River at Doctortown, Ga	13,600	13,780	17,000	71	+16	7,340	4,740	29
2–3205	Suwannee River at Branford, Fla	7,880	6,970	6,360	62	-3	4,080	2,640	30
2–3580	Apalachicola River at Chattahoochee, Fla	17,200	22,330	21,900	69	+44	10,800	6,980	30
2–4670	Tombigbee River at Demopolis lock and dam near Coatopa, Ala	15,400	22,570	37,580	104	+55	8,600	5,560	29
2–4895	Pearl River near Bogalusa, La	6,630	9,263	15,070	116	+52	3,220	2,080	30
3–0495	Allegheny River at Natrona, Pa	11,410	[1] 19,210	27,780	76	+6	31,800	20,600	27
3–0850	Monongahela River at Braddock, Pa	7,337	[1] 12,360	21,200	116	+47	14,900	9,630	27
3–1930	Kanawha River at Kanawha Falls, W.Va	8,367	12,530	13,790	86	+19	13,600	8,790	26
3–2345	Scioto River at Higby, Ohio	5,131	4,513	6,710	90	+88	4,880	3,150	29
3–2945	Ohio River at Louisville, Ky[2]	91,170	114,100	192,700	100	+36	207,000	134,000	26
3–3775	Wabash River at Mount Carmel, Ill	28,635	27,030	26,720	58	+50	36,600	23,700	30
3–4690	French Broad River below Douglas Dam, Tenn	4,543	[1] 6,794	7,386	78	+54	......	......	...
4–0845	Fox River at Rapide Croche Dam, near Wrightstown, Wis[2]	6,150	4,185	3,653	55	-10	......	......	...
02MC002 (4–2643.31)	St. Lawrence River at Cornwall, Ontario–near Massena, N.Y[3]	299,000	241,100	259,500	104	-2	248,000	160,300	30
050115	St. Maurice River at Grand Mere, Quebec	16,300	25,300	92,300	222	+268	22,500	14,500	30
5–0825	Red River of the North at Grand Forks, N. Dak	30,100	2,524	981	11	+7	620	400	30
5–1335	Rainy River at Manitou Rapids, Minn	19,400	12,950	7,270	44	+2	6,420	4,150	22
5–3300	Minnesota River near Jordan, Minn	16,200	3,412	1,426	18	+35	1,360	880	27
5–3310	Mississippi River at St. Paul, Minn	36,800	[1] 10,580	8,505	31	+77	10,000	6,460	30
5–3655	Chippewa River at Chippewa Falls, Wis	5,600	5,110	11,760	120	+232	......	......	...
5–4070	Wisconsin River at Muscoda, Wis	10,300	8,613	14,370	94	+67	......	......	...
5–4465	Rock River near Joslin, Ill	9,551	5,852	7,880	94	+1	8,200	5,300	30
5–4745	Mississippi River at Keokuk, Iowa	119,000	62,570	92,316	79	+58	77,600	50,200	30
6–2145	Yellowstone River at Billings, Mont	11,796	6,986	2,813	77	+18	5,600	3,620	30
6–9345	Missouri River at Hermann, Mo	524,200	79,750	52,630	55	+81	45,000	29,100	30
7–2890	Mississippi River at Vicksburg, Miss[4]	1,140,500	573,600	436,300	44	-14	610,000	394,000	27
7–3310	Washita River near Durwood, Okla	7,202	1,414	296	27	-60	450	290	30
8–2765	Rio Grande below Taos Junction Bridge, near Taos, N. Mex	9,730	724	243	37	-48	250	160	30
9–3150	Green River at Green River, Utah	40,600	6,366	3,374	49	+56	3,570	2,310	30
11–4255	Sacramento River at Verona, Calif	21,257	19,150	15,032	67	-29	10,800	6,980	27
13–2690	Snake River at Weiser, Idaho	69,200	18,170	17,310	82	+18	26,400	17,100	29
13–3170	Salmon River at White Bird, Idaho	13,550	11,290	11,451	109	+100	24,590	15,900	29
13–3425	Clearwater River at Spalding, Idaho	9,570	15,570	16,818	58	+57	36,030	23,300	30
14–1057	Columbia River at The Dalles, Oreg[5]	237,000	194,600	166,400	74	+49	......	......	...
14–1910	Willamette River at Salem, Oreg	7,280	23,810	28,600	100	+55	16,700	10,800	26–30
15–5155	Tanana River at Nenana, Alaska	25,600	23,850	10,880	160	+50	13,000	8,400	30
8MF005	Fraser River at Hope, British Columbia	83,800	96,400	63,910	108	+45	112,600	72,800	29

[1] Adjusted.
[2] Records furnished by Corps of Engineers.
[3] Records furnished by Buffalo District, Corps of Engineers, through International St. Lawrence River Board of Control. Discharges shown are considered to be the same as discharge at Ogdensburg, N.Y. when adjusted for storage in Lake St. Lawrence.
[4] Records of daily discharge computed jointly by Corps of Engineers and Geological Survey.
[5] Discharge determined from information furnished by Bureau of Reclamation, Corps of Engineers, and Geological Survey.
*The U.S. station numbers as listed in this table are in a shortened form previously in use, and used here for simplicity of tabular and map presentation. The full, correct number contains 8 digits and no punctuation marks. For example, the correct form for station number 1–3185 is 01318500.

HYDROGRAPHS OF FOUR LARGE RIVERS



WATER RESOURCES REVIEW

April 1981

Based on reports from the Canadian and U.S. field offices; completed May 12, 1981

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EXPLANATION OF DATA

Cover map shows generalized pattern of streamflow for April based on 20 index stream-gaging stations in Canada and 130 index stations in the United States. Alaska and Hawaii inset maps show streamflow only at the index gaging stations which are located near the points shown by the arrows.

Streamflow for April 1981 is compared with flow for April in the 30-year reference period 1941–70. Streamflow is considered to be *below the normal range* if it is within the range of the low flows that have occurred 25 percent of the time (below the lower quartile) during the reference period. Flow for April is considered to be *above the normal range* if it is within the range of the high flows that have occurred 25 percent of the time (above the upper quartile).

Flow higher than the lower quartile but lower than the upper quartile is described as being *within the normal range.* In the Water Resources Review the median is obtained by ranking the 30 flows of the reference period in their order of magnitude; the highest flow is number 1, the lowest flow is number 30, and the average of the 15th and 16th highest flows is the median.

The normal is an average (but not an arithmetic average) or middle value; half of the time you would expect the April flows to be below the median and half of the time to be above the median. Shorter reference periods are used for the Alaska index stations because of the limited records available.

Statements about *ground-water levels* refer to conditions near the end of April Water level in each key observation well is compared with average level for the end of April determined from the entire past record for that well or from a 20-year reference period, 1951–70. *Changes in ground-water levels,* unless described otherwise, are from the end of March to the end of April.

The Water Resources Review is published monthly. Special-purpose and summary issues are also published. Issues of the Review are free on application to the Water Resources Review, U.S. Geological Survey, Reston, Virginia 22092.

CHLORIDE IN NATURAL CONTINENTAL WATER—A REVIEW

The abstract (slightly abridged) and table below are from the report, *Chloride in natural continental water—a review,* by J. H. Feth: U.S. Geological Survey Water-Supply Paper 2176, 30 pages, 1981. This publication is the first in the Geological Survey's Water-Supply Paper (WSP) series to be published in a recently adopted new format. The larger page size (8½×11 inches) will permit greater flexibility in presentation of information, especially of tables and illustrations. This report may be purchased for $2.00 from U.S. Geological Survey, Eastern Distribution Branch, 604 S. Pickett St., Alexandria, VA 22304 (check or money order payable to the U.S. Geological Survey); or from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402 (payable to the Superintendent of Documents).

ABSTRACT

Chlorine is the 15th most abundant element in the outer lithosphere but is the most abundant in the hydrosphere, which is dominated by the oceans. Chloride (Cl) ranks 5th in abundance among the ions in average river water. Cl is probably present in all natural waters, although below detection limits in some. The geochemistry of chlorine is largely that of the Cl ion. The ready solubility of Cl salts and general noninvolvement in oxidation-reduction reactions makes chlorine one of the more mobile of elements.

The concentrations of chlorine in rocks are poorly known. (See table 1.) Estimates suggest that in igneous rocks concentrations are less than 500 ppm (parts per million), in sedimentary rocks, excluding evaporites, from 10 or less to about 1,500 ppm. In a few individual minerals such as sodalite, apatite, mica, and hornblende, where chlorine replaces hydroxyl, and in scapolite, the concentration may reach 50,000 ppm or more. I found virtually no information about concentrations of chlorine in metamorphic rocks except those containing scapolite.

Cl is present in the tissues of all plants and in all animals where it exercises important physiological controls. Concentrations in living tissue are estimated to range from 100 to 1,000 ppm.

In the oceans, the average concentration of Cl is about 19,000 mg/L (milligrams per liter), its mass about 270×10^{14} metric tons. Its mass in the hydrosphere other than the sea is unknown but probably insignificant by comparison. Concentrations of Cl in precipitation range from less than 0.02 to more than 200 mg/L in samples taken on exposed sea coasts during storms. In surface waters the concentrations range from less than 1 to more than 280,000 mg/L, in ground waters the range is from less than 1 to more than 200,000 mg/L.

Cl is the ion that dominates most discussion of "cyclic salts." Unquestionably there is a Cl cycle in which Cl from the sea is incorporated in masses of moving air—then in precipitation—then runoff and ground water—and finally in water discharged from the continents back to the sea. The magnitude of the Cl contribution from precipitation to runoff and ground water remain uncertain. Where surface and ground waters contain less than 5 or 10 mg/L Cl, atmospheric sources may be the major contributors. But where high concentrations of Cl are involved, the data available indicate that continental sources can supply almost all the Cl load.

A problem is posed by those numerous places where, year after year, ground water carries a virtually constant concentration of Cl, large or small. There is implication in those occurrences of a supply that either releases Cl ions at constant rate or that is itself renewed at a constant rate. Understanding of Cl contributions from the atmosphere to both surface and ground water requires, among other things, that we learn a great deal more about the volume of aqueous precipitation and especially about the chemical character of precipitation, including rain, dry fallout, and bulk precipitation, the geochemically active mixture of aqueous precipitation and dry fallout.

There are various obvious sources from which Cl gets into natural water. These include salt particles and brine droplets airborne from the sea, beds of halite, saline crusts of desert basins, magmatic gases, and human and animal wastes. These obvious sources do not seem adequate to explain Cl concentrations found in water in many areas. They do not, for instance, seem to explain the fact that many fault-zone springs have high Cl concentrations. Existing information on the chlorine content of rocks—and what little we know of Cl in soils—does not suggest that weathering of rocks and leaching of soils would supply the quantities of Cl found (and continually renewed) in surface and ground water.

Table 1.—*Chlorine in some rocks and minerals*

[Concentrations are in parts per million by weight]

Rock or mineral	Rankama and Sahama (1950 table 5.52)	Correns (1956, various tables)	Parker (1967, table 19)	Johns and Huang (1967, table 7)	Shaw (1960 p. 218)	Gulbrandsen (1966, table 1)
Igneous rocks undiff.	314	--	--	--	--	--
Ultramafic rocks	--	340–1,000	50–85	40–300	--	--
Basalt, andesite	--	20–1,100	50–60	50–400	--	--
Granitic rocks	--	80–800	100–240	130–800	--	--
Rhyolitic rocks	--	20–150	--	--	--	--
Obsidian, pitchstone	--	80–1,280	--	--	--	--
Syenite	--	200–970	520	400–2,170	--	--
Clay and shale	--	50–450	160	47–180	--	--
Shale	--	--	180	--	--	--
Sandstone, wacke	trace to 20–100	10	20, 70	--	--	--
Carbonate rocks	200	20–2,000	150	130–660	--	--
Phosphorite	--	--	--	--	--	100–400
Apatite	--	530–58,000	--	--	--	--
Fluorite	--	170 (p. 188)	--	--	--	--
Hornblende	--	210–6,000	--	--	--	--
Mica	--	20–3,000	--	--	--	--
Scapolite	--	--	--	--	500–33,000	--
Sodalite	--	70,000 (p. 188)	--	--	--	--

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